PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) PROCESS AND APPARATUS FOR STERILIZATION OR PASTEURIZATION

(71) We, A.T.A.D., APPROVISIONNEMENT-TRANSPORT AERIEN-DISTRIBUTION, of 10 Avenue Matignon, 75 Paris 8ème (France), a French Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a process of sterilization or pasteurization, in particular or lacteal products, without bringing in external heat. The invention is also concerned with apparatus for sterilizing or pasteurizing, which puts this process into practice and thus does not require an external source of heat. Finally, the invention includes the sterilized or pasteurized products obtained by this process.

It is recalled that, in conventional processes of sterilization or pasteurization by thermal action, the product to be sterilized or pasteurized is subjected to a certain temperature for a determined duration. Thus for milk, sterilization is currently carried out in bulk at 130 to 150°C for a few seconds or several tens of seconds by putting it in contact with a heated wall or with vapour. These two means of heating by contact have the disadvantage of subjecting the milk to a veritable thermal shock, the particles of milk being put abruptly in the presence of particles of metal or of vapour much hotter than themselves. This results in a deterioration of the organoleptic and nutritive qualities of the milk, as a function of the temperature and the duration of contact, as well as a certain segregation of the constituents, which often necessitates a subsequent operation of homogenization. Besides, when the heating of the milk is effected by contact with vapour, it is indispensable to eliminate the water thus added to the milk, and furthermore, vapour sterilization of milk is not permitted by the legislation of certain countries.

In these conventional processes, in which the milk is heated to a high temperature and is maintained for a certain duration at such a temperature, three effects are produced: first a useful biological effect, namely the destruction of micro-organisms contained in the milk, this destruction being precisely the object of the sterilization; an undesirable chemical effect, namely the chemical modification of certain fragile organic molecules, which leads to alterations of the color and the organoleptic qualities and the degradation of a part of the proteins and vitamins of the original milk, sometimes even ending in a veritable "cracking" or "crusting" when particles of the product remain stuck to the heated wall as a result of defective or interrupted operation of the sterilization apparatus; finally a physical effect, also undesirable, namely the segregation of the milk constituents, in particular the cream.

Now the research pursued by the present applicants showed that it was advantageous to carry out the sterilization or pasteurization, in particular of lacteal products, by subjecting the product to be sterilized or pasteurized, for a very reduced duration of the order of a fraction of a second, simultaneously to a temperature of sterilization and to a mechanical force, which, by their combined effects, achieve practically instantaneously the desired destruction of the micro-organisms, without degrading the organic molecules, since the sterilization temperature is applied for an extremely short duration. In fact, in the process of the applicants, the product to be sterilized is brought to the sterilization temperature, not by contact with a wall or vapour at a temperature much hotter than itself, thus causing a thermal shock that causes molecular degradation, but by progressive internal heating, within the product itself, without bring-

ing in external heat. In this manner, a sterilized product is obtained which is substantially identical, with respect to its chemical and physical composition, to the initial product, but which is rid of its germs, which are harmful both from the point of view of hygiene and from the point of view of preservation. Thus, practically the only effect of the operation of sterilization by the process according to the present invention is to destroy the micro-organisms, while leaving the chemical and physical composition of the initial product unchanged, due to the fact that the thermal effect is progressive and of very limited duration (a fraction of a second), whereas, in the conventional processes of sterilization by heating, this thermal effect was brutal and of long duration (several seconds or tens of seconds) and accordingly resulted in chemical degradation and physical segregation. The process according to the present invention separates the useful effect of sterilization, that it to say of destruction of the germs, from the troublesome effects of degradation and segregation.

According to the present invention there is provided a process for the pasteurisation or sterilization of a liquid food product, for example a lacteal product comprising passing the product between closely-spaced relatively moving surfaces to internally heat the product by molecular friction in a period of less than one second to the pasteurisation or sterilization temperature, and simultaneously subject the product to centrifugal force to pressurise the product, the internal heating and the centrifugal force being effective to destroy micro-organisms present in the product.

In pasteurisation of a product according to the invention the product may be maintained at a temperature of approximately 80°C for less than one second. In sterilization of a product according to the invention, the product is preferably maintained at a temperature between 135-145°C for less than one second

It will be appreciated that the boiling point of a liquid increases with increase in pressure, and that in the case of liquids, for example milk, in which boiling of the liquid would cause degradation, the pressure must be high enough to enable sterilisation to be carried out at a temperature below boiling point.

The process of the invention can be put into practice in apparatus comprising at least two surfaces or walls movable in relative movement one with respect to the other and between which the product to be sterilized or pasteurized passes, the speeds of relative displacement of the wall or walls and the product being such that they assure, on the one hand, the bringing of the product to the desired temperature, and on the other hand, the application of a mechanical force to the particles of the product sufficient to degrade, and even destroy, the cell walls of the micro-organisms that may be present in the product to be sterilized or pasteurized.

The distance between the two co-operating surfaces that are in relative movement with respect to each other and between which the product to be sterilized passes, should be very small, preferably less than 0.5 millimeter, and preferably in the range of 0.2 to 0.3 millimeter.

The apparatus can advantageously comprise:

—either a disc driven in rotation about its axis at the interior of a casing, the distance between each movable face of the disc and the opposed fixed face of the casing being in the range of 0.2 to 0.3 millimeter; the product to be sterilized is brought into the space between the disc and the casing in the neighbourhood of the axis of rotation of the disc, whereas the sterilized product escapes in the neighbourhood of the periphery of the disc, the mechanical force being constituted by the centrifugal force which acts on the product driven from the centre towards the periphery of the disc;

—or a truncated cone driven in rotation about its axis at the interior of a frusto-conical casing of the same conicity, the distance between the movable surface of the rotary truncated cone and the fixed surface of the casing being in the range of 0.2 to 0.3 millimeter; the product to be sterilized is introduced in the neighbourhood of the small end of the truncated cone, whereas the sterilized product escapes in the neighbourhood of the large end of the truncated cone, the mechanical force being constituted by the centrifugal force which acts on the product. The rotary truncated cone may have a series of helical projections on its pheriphery.

In the process and the apparatuses mentioned above, there is achieved, at the same time as the application of a mechanical force having a disruptive effect on the cell walls of the micro-organisms, the heating of the particles of the product to be sterilized by friction against walls with respect to which the product is displaced, it being understood that these walls are not heated to a temperature greater than that of the product which comes into contact with them (as is the case in the prior conventional processes and apparatuses for thermal sterilization or pasteurization); this avoids any thermal shock and consequently chemical degradation or physical segregation of the various constituents of the product to be sterilized, only the micro-organisms

that may be present in the product to be sterilized being destroyed, this destruction being practically total.

Indeed, the applicants have noticed with surprise that the simultaneous application of a sufficient mechanical force, adapted to destroy or at least degrade the cell walls, and of a certain temperature permits effective sterilization to be achieved at a lower temperature and/or for a shorter duration than in the purely thermal processes using only a certain temperature for a certain duration. Due to the fact that the product to be sterilized, in particular a lacteal product, is subjected to a thermal sterilization effect at a lower temperature and/or for a shorter duration, the constituents of the product do not undergo any appreciable chemical degradation and/or physical segregation. Finally, a product is obtained which is substantially identical to the initial product before sterilization — and this is particularly true for milk — apart from the fact that the micro-organisms which may have been present were destroyed by the combined effect of the temperature and the mechanical force.

In order to achieve, in the best possible conditions, the selective destruction of the micro-organisms without appreciable degradation or segregation, the applicants discovered that it was advantageous to operate in the following conditions for milk: temperature not exceeding 145°C, duration of application of the maximum temperature not exceeding a few tenths of a second and less than one second, passage of the product to be sterilized between surfaces or walls separated by a distance not greater than 0.5 millimeter, and maximum speed of relative displacement (in the neighbourhood of the periphery of the disc in the case of a disc apparatus) greater than 50 meters per second and preferably in the range of 60 to 80 meters per second (or more, in particular in the case of pasteurization).

In these preferred conditions, the milk remains absolutely stable in the course of the sterilization treatment, even in the case in which it has an excess of albumen, calcium and/or acidity; in particular, no coagulation manifests itself in the course of the treatment and sterilized milk is obtained which remains a complete food with all the nutritive value of the original milk without appreciable loss of vitamins, thiamine, lysine and other amino-acids; finally the digestibility of the protein of the milk is not altered by the sterilization treatment.

The invention will now be illustrated, merely by way of example, by the following specific description, with reference to the accompanying drawings, of particular embodiments of the apparatus of the invention, and the manner in which the process of the invention is carried out with the aid of these embodiments.

In the drawings:

Figures 1 and 2 represent, respectively in section and in lateral elevation, an apparatus having a flat disc for carrying out the process according to the invention;

Figure 3 represents a schematic diagram of an overall sterilizer comprising a disc type apparatus according to Figures 1 and 2;

Figure 4 represents, in lateral elevation, the disposition of the disc type apparatus according to Figures 1 and 2;

Figures 5 and 6 represent, respectively in longitudinal section and in lateral elevation, an apparatus analogous to that of Figures 1 and 2, but comprising a slightly bulging disc;

Figure 7 is a section through an apparatus having a rotatable truncated cone, for carrying out the process according to the invention;

Figure 8 represents a curve illustrating the rise of temperature (given on the ordinate in degrees C) as a function of the time (given on the abscissa in tenths of a second) in a sterilization apparatus, in particular of the disc type, according to the invention;

And Figure 9 represents, in section, another embodiment of a flat disc type apparatus.

Referring first of all to Figures 1 and 2, which show one embodiment of a sterilization (or pasteurization) apparatus using a rotary flat disc, it is seen that this embodiment of a device for carrying out the process of the present invention comprises essentially at flat disc 1 driven in rotation, in the direction of the arrow *f*, about its axis XX at the interior of a casing 2. The distance *e* between each movable face 1*a* and 1*b* of the disc 1 and the corresponding, opposed fixed face 2*a* and 2*b* of the casing is in the range of 0.2 to 0.3 millimeter. The product to be sterilized, for example milk, is brought into the space 3 comprised between the disc 1 and the casing 2 at 4 in the neighbourhood of the axis of rotation XX of the disc 1 (see also Figure 3), whereas the sterilized product escapes at 5 in the neighbourhood of the periphery 6 of the disc 1 (see also Figure 3). The mechanical force is constituted by the centrifugal force which acts on the product driven from the centre (axis XX) towards the periphery 6 of the disc 1, whereas the heating of the product is assured by the friction of the particles of this product both on the movable faces 1*a* and 1*b* of the disc 1 and on the fixed faces 2*a* and 2*b* of the casing 2 with respect to which the product is displaced at high speed.

In the embodiment illustrated in Figures 1 and 2, the flat disc 1 (having a plane

of symmetry YY), which has a thickness of 16 millimeters, is carried by a shaft 7 housed in a sleeve 8 itself carried by blocks 9. The shaft 7 turns at the interior of the sleeve 8 due to roller bearings 10 which are maintained in position against internal shoulders 8*a* of the sleeve 8 by means of threaded plugs 11 and 12 fitted into the two ends of the sleeve 8. The shaft 7 passes through these two plugs, and moreover, the plug 11 carries a bearing line 11*a*. Furthermore, two packings 13 assure the tightness at the two ends of the chamber 14 which is located between the central parts of the shaft 7 and of the sleeve 8, and which communicates with the space 3 through the annular passages 15. In this manner, the supply of the product to be sterilized (or pasteurized) can be effected, if it is desired, into the chamber 14, thus cooling the shaft 7 somewhat while heating the product.

On one end 7*a* of the shaft 7, which passes through the corresponding plug 12, is mounted one of the halves 16*a* of a coupling 16 whose other half 16*b* is fixed to the shaft 17 of an electric motor 18.

In Figure 2, one of the cheeks 2*e* of the casing 2 can be seen in a more precise manner. The cheek 2*e* is fixed to the other cheek 2*f* by means of pins 19, and both these cheeks carry reinforcing ribs or walls 20. Still in this Figure 2, there can be seen the inlet tubing 4*a* for the product to be sterilized (or pasteurized) opening out at the point 4, and the outlet tubes 5*a* opening out at the points 5 for the evacuation of the sterilized (or pasteurized) product.

The embodiment of Figures 5 and 6 is identical to the embodiment of Figures 1 and 2, and the same reference numerals have been used in these four figures to designate similar elements, the sole difference being the fact that, in the embodiment of Figures 5 and 6, the rotary element is not a flat disc 1 but a slightly bulging disc 1A, so as to have in half-section the profile of a truncated cone. Thus the faces 1*c* and 1*d* of the disc 1 are slightly inclined to the plane of symmetry YY of the disc 1*a* instead of being parallel to this plane, as in the embodiment of Figure 1. It is the same for the faces 2*c* and 2*d* of the casing 2A which are opposed to the faces 1*c* and 1*d*. In the embodiment of Figures 5 and 6, the spacing *e* between the opposed walls 1*c*-2*c* on the one hand, and 1*d*-2*d* on the other hand, which delimit the space 3, is in the range of 0.2 to 0.3 millimeters.

In Figure 3, an entire sterilization installation has been shown (by way of non-limiting example) which comprises, in addition to the apparatus 21 having its rotary disc (between two cheeks 2*e* and 2*f*) driven by the motor 18 through the coupling 16, the following elements:

— a vat 22, intended to receive the product, in particular the lacteal product to be sterilized (or possibly pasteurized), with, at the interior, an emptying portion 22*a*;

— a pump 23, adapted to receive the product to be sterilized from the vat 22 through a pipe 24, a three-way valve 25 and a conduit 26;

— a by-pass valve 27, disposed in parallel with the pump 23, the parallel unit 23-27 being supplied through the conduit 26 and discharging into a conduit 28 which supplies, by its branches 28*a* and 28*b* in parallel, the chamber 14 of Figure 1 or Figure 5;

— an outlet conduit 29, taking off the sterilized product which exits at the periphery 6 of the disc 1 (through the tubes 5*a* of Figure 2 or Figure 6), this conduit 29 being provided with a temperature sensor 30 that co-operates with a device 31 for indicating the temperature;

— a regulation valve 32, which can be controlled by a pneumatic capsule, checked by a pneumatic regulator in order to assure a weight of flow such that the sterilized liquid reaches the desired temperature, the checking being in this case achieved from the sensor 30;

— a two-zone heat exchanger 33 connected to receive the sterilized product through the conduits 34 and 35 and to receive cooling water through the pipe 36, the exchanger effecting the cooling of the sterilized product, which exits through the conduit 37 and which is available at 38, whereas the water, which is heated by the exchange of heat with the sterilized product, exits through the pipe 39;

— a pressure sensor 40, co-operating with a device 41 for indicating the pressure at the interior of the unit 21;

— a device 42 for initially purging the air at the interior of the unit 21, the purged products being sent through the conduit 43 into the portion 22*a* of the vat 22;

— a water circulation system (for example for testing the sterilization apparatus or for putting this apparatus under load), which comprises an inlet pipe 44 for the inlet of water that can be sent by the valve 25 towards the conduit 26, a conduit 35*a* that can be supplied in place of the conduit 35 by a three-way valve 45, the outlet from the exchanger 33 being then made through the conduit 46 towards the emptying portion 22*a*, and an emptying pipe 47 which evacuates the water at 48, the outlet 48 also being able to be supplied from the valve 25 through the pipe 49.

The installation of Figure 3 operates as follows:

In the beginning, water is made to arrive at 50, and this water is sent through the valve 25 towards the conduit 26, from where

the pump 23 sends it into the conduits 28, 28*a* and 28*b* and, from there, into the chamber 14 of the unit 21. The rotation of the disc 1 of the unit 21 heats the water which is evacuated, in the liquid state or in the vapour state according to the adjustment temperature, through the conduits 29, 34 and 35*a*. In the exchanger 33 this water is cooled by contact with cold water arriving through the pipe 36. The treated water, thus cooled, exits through the conduit 46, and from there, it is sent through the pipe 47 to the outlet point 48.

When the apparatus has been started and adjusted, the position of the valves 25 and 45 is modified (after the arrival of water at 50 has been cut off). The contents of the vat 22 pass through the conduits 24 and 26, the pump 23 and the conduits 28, 28*a* and 28*b* in order to arrive in the chamber 14 of the unit 21. The product is sterilized or pasteurized in the chamber 3 of this unit and exits at the periphery 6 of the disc. The sterilized or pasteurized product follows the conduits 29, 34 and 35 to reach the exchanger 33, where it is cooled before exitting through the conduit 37 and reaching the outlet 38.

In Figure 4, there is shown the (possible) relative positions of the vat 22, the two-zone exchanger 33, of which one zone is for the treated product and the other zone is for the test water, the unit 21, the coupling 16 and the motor 18.

So far, apparatuses have been illustrated for carrying out the process of sterilization or pasteurization according to the invention, comprising a disc, flat or bulging, rotatable in a casing.

The invention is also applicable to other types of members rotatable in a casing, for example to a frusto-conical drum rotating in a similarly frusto-conical casing, as illustrated in Figure 7.

In this figure, an embodiment of an apparatus for carrying out the process according to the present invention has been illustrated which comprises a frusto-conical drum 51 which rotates in a similarly frusto-conical casing 52 having the same axis ZZ as the drum 51, a distance *e* being provided between the fixed wall of the casing 52 and the movable wall of the drum 51. This drum is driven by a shaft 53, also of axis ZZ, driven by a motor (not shown), the shaft 53 rotating in a casing 54 in which it is maintained by bearings 55. A packing 56 is provided for assuring the tightness and preventing the product to be sterilized — which arrives at 57 in the space or chamber 58 between the casing 52 and the drum 51 — from reaching the interior of the casing 54.

The operation of the device illustrated in Figure 7 is the following:

The product to be sterilized (or pasteurized), which may possibly be preheated, arrives at 57, either by simple gravity, or by being driven under pressure. It reaches the chamber 58 in which it is heated by the effect of the internal friction resulting from the rotation of the drum 51 in the casing 52, the distance *e* being in the range of 0.2 to 0.3 millimeter. The product to be sterilized (or pasteurized) follows a helical path from the inlet 57 to the outlet 59, and it is thus subjected to a centrifugal force which is added to the thermal heating effect to destroy the micro-organisms which may be present in the product arriving at 57; thus the product exitting at the outlet 59 is sterilized or pasteurized according to the temperature reached by the product at the end of its path in the chamber 58.

If desired, one or several helical projections 60 can be provided on the periphery of the drum 51 in order to impart, in a positive manner, a helical path on the product to be sterilized (or pasteurized) in the chamber 58.

In all the embodiments described up till now, with reference to the drawings, the product to be sterilized or pasteurized passes between a fixed surface and a movable surface, but of course this product can be passed between two movable surfaces, rotating, for example, in opposite directions, without departing from the general idea of the invention.

In all cases, the heating of the product to be sterilized or pasteurized is achieved, without bringing in external heat, under the effect of the friction of the product between the walls in relative movement with respect to this product, with a progressive increase of the temperature in a very short time.

Figure 8 illustrates the evolution of the temperature as a function of the time in a product to be sterilized which is treated in a device of the type illustrated in Figures 1-2, 5-6 or 7, supposing that the product arrives cold at a temperature of 10°C. It is seen that at the outlet, at the end of 0.6 second, the temperature reaches 145°C, the product being heated progressively without ever being in contact with a wall hotter than itself, which avoids any thermal shock. It will also be noticed that the product passes from about 65°C to about 145°C in a tenth of a second, and that consequently it remains only a fraction of a second at temperatures at which there is a risk of producing degradations of the structure of its components, it being understood that it is appropriate to cool the sterilized product rapidly when it exits from the device according to the invention in order to avoid maintaining this product at 145°C after its outlet from the device.

Figure 9 is a sectional view of another embodiment of a flat disc type sterilizer putt-

ing the process of the present invention into practice.

The liquid to be sterilized is sent into a sterilizer comprising a disc 101 mounted rotatably in the body 102 of the apparatus.

This disc 101 is rigid with a shaft 103 which is carried by bearings 104 and 105 and is driven by the intermediary of a coupling 106 by means of a motor 107.

The liquid is introduced, either by gravity or by means of a pump, through conduits 108 and 109 opening out near the shaft 103.

The tightness between the shaft 103 and the fixed body 102 of the apparatus is assured by packings 110 and 111.

The air contained in the installation is eliminated by means of a purger 112, and the liquid, subjected to friction between the rotary disc 101 and the body 102 of the apparatus, is brought to a high temperature.

By the effect of centrifugal force, the liquid is driven towards the part of the body of the apparatus remote from the shaft, and exits from the apparatus through a conduit 113 provided with a flow regulator device 114 having manual or automatic control.

The apparatus is completed by instruments for measuring the temperature of the liquid 115, its pressure 116 and its rate of flow 117.

The heating temperature can be adjusted either by varying the speed of rotation of the disc or by varying the rate of flow of the liquid.

By way of example, the disc has a diameter of 400 millimeters and a thickness of 16 millimeters; it is positioned at 0.3 millimeter from the walls and is driven at 3.000 revolutions per minute.

The temperature reached in these conditions is 145°C for a flow rate of 120 litres/hour of cream (milk) to be sterilized.

The apparatus can be completed, according to the chosen use, by conventional temperature exchangers disposed upstream of the apparatus for assuring preheating, or at the outlet of the apparatus for assuring energetic cooling.

In this manner, excellent sterilization is obtained, in particular with the apparatuses of Figures 1 and 2 or 9, with practically complete destruction of the micro-organisms and without degradation or segregation of the components.

Here are the results, given by way of example, of bacteriological analyses or cream effected before and after sterilization:

BEFORE STERILIZATION

Cream A

Numbering of thermoresistant anaerobic bacteria (sporulated) after 30 minutes of heating at 80°C — deep gelose VF medium in tubes.
. After 7 days at 37°C: more than 10.000 germs/1 cm³.

Numbering of thermoresistant aerobic bacteria (sporulated) after 30 minutes of heating at 80°C — nutritious gelose in Petri boxes.
. After 3 days at 37°C: 75,000 germs/1 cm³.

Numbering of all germs.
Two layer method, tryptone Agar medium in Petri boxes (Buttiaux)
. After 3 days at 30°C: more than 10,000,000 germs/1 cm³.
. After 3 days at 6°C: 1,800,000 germs/1 cm³.

Coliform germs on green brilliant broth (48 hours at 30°C):
more than 1.000 germs/1 cm³.

Escherichia coli (Mackenzie test)
48 hours at 44°C, on green brilliant broth and peptoned water:
more than 1,000 germs/1 cm³.

Pathogenic staphylococcus on Chapman medium:
no germ/1 cm³.

Salmonella and Shigella research:
no germ/1 cm³.

AFTER STERILIZATION

Cream B

Numbering of thermoresistant anaerobic bacteria (sporulated) after 30 minutes of heating at 80°C deep gelose VF medium in tubes.
. After 7 days at 37°C: no germ/1 cm^3.

Numbering of thermoresistant aerobic bacteria (sporulated) after 30 minutes of heating at 80°C nutritious gelose in Petri boxes.
. After 7 days at 37°C: no germ/1 cm^3 at 1/10.

Numbering of all germs.
Two layer method, tryptone Agar medium in Petri boxes (Buttiaux)
. After 3 days at 30°C: no germ/1 cm^3 at 1/10.
. After 3 days at 6°C: no germ/1 cm^3 at 1/10.

Coliform germs on green brilliant broth (48 hours at 30°C):
no germ/1 cm^3.

Escherichia coli (Mackenzie test)
48 hours at 44° on green brilliant broth and peptoned water:
no germ/1 cm^3.

Pathogenic staphylococcus on Chapman medium:
no germ/1 cm^3.

Salmonella and Shigella research:
no germ/1 cm^3.

As a result, whatever embodiment is adopted, a process and apparatus are provided whose operation is sufficiently clear from the foregoing that no more need be said in this connection.

The process and apparatus according to the present invention have numerous advantages with respect to the prior art processes and apparatuses of the type in question, in particular the following advantages:

First of all, they permit sterilization or pasteurization to be achieved in excellent conditions, in particular for lacteal products.

They assure practically absolute destruction of micro-organisms which may be present in the product to be treated.

Apart from the destruction of the micro-organisms that may be present, the product undergoes practically no alteration; in particular, the delicate organic molecules are not degraded and the various constituents do not undergo any segregation effects.

The sterilization or pasteurization is very rapid and it can be carried out continuously.

They do not necessitate the bringing in of external heat.

WHAT WE CLAIM IS:—

1. A process for the pasteurisation or sterilisation of a liquid product, for example a lacteal product comprising passing the product between closely-spaced relatively moving surfaces to internally heat the product by molecular friction in a period of less than one second to the pasteurisation or sterilisation temperature, and simultaneously subject the product to centrifugal force to pressurise the product, the internal heating and the centrifugal force being effective to destroy micro-organisms present in the product.

2. A process as claimed in claim 1 for pasteurisation of the product, wherein the product is maintained at a temperature of approximately 80°C for less than one second.

3. A process as claimed in claim 1 for sterilisation of the product, wherein the product is maintained at a temperature between 135-145°C for less than one second.

4. A process as claimed in any of claims 1-3, wherein the relatively moving surfaces are spaced from one another by less than 0.5 millimeter.

5. Apparatus for the pasteurisation or sterilisation of a liquid food product, for example a lacteal product, comprising relatively movable members having opposing surfaces spaced apart by less than 0.5 millimeter, and means for injecting the product to be pasteurised or sterilised between the two surfaces, the speeds of relative movement of one or both surfaces and the product being such that they ensure internal heating of the product to the pasteurisation or sterilisation temperature and application to the particles of the product of a centrifugal froce to place the product under pressure, the internal heating and the

centrifugal force being effective to destroy micro-organisms present in the product.

6. Apparatus as claimed in claim 5, comprising a disc rotatable about its axis in a casing, drive means for rotating the disc at a peripheral linear speed in excess of 50 metres per second, and means for feeding the product under pressure into the space between the disc and the casing in the vicinity of the axis of rotation of the disc, the disc and casing constituting said two members, the gap between each side face of the disc and the opposite fixed face of the casing being between 0.2 and 0.3 millimetre, and the casing having a port in the vicinity of the periphery of the disc for discharge of the product, the centrifugal force acting on the product driving it from the centre towards the periphery of the disc.

7. Apparatus as claimed in claim 5, comprising a truncated cone rotatable about its axis inside a frusto-conical casing of the same conicity, drive means for rotating the cone within the casing, and means for feeding the product under pressure into the casing in the vicinity of the small end of the truncated cone, the cone and casing constituting said two members, the gap between the surface of the cone and the fixed surface of the casing being between 0.2 and 0.3 millimetre, and the casing having a port in the vicinity of the large end of the cone for discharge of the product, the centrifugal force acting on the product driving it away from the axis of the cone and towards the large end thereof.

8. Apparatus as claimed in claim 7, wherein the rotary truncated cone has a series of helical projections on its peripheral surface.

9. Apparatus for sterilization or pasteurization substantially as described hereinbefore with reference to and as illustrated in Figures 1 and 2 or Figure 3 or Figure 4 or Figures 5 and 6 or Figure 7 or Figure 9 of the accompanying drawings.

10. A product, in particular a lacteal product, sterilized or pasteurized by the process according to any of claims 1-4.

11. A product, in particular a lacteal product, sterilized or pasteurized in the apparatus according to any of claims 5-8.

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1,217,959 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEET 1

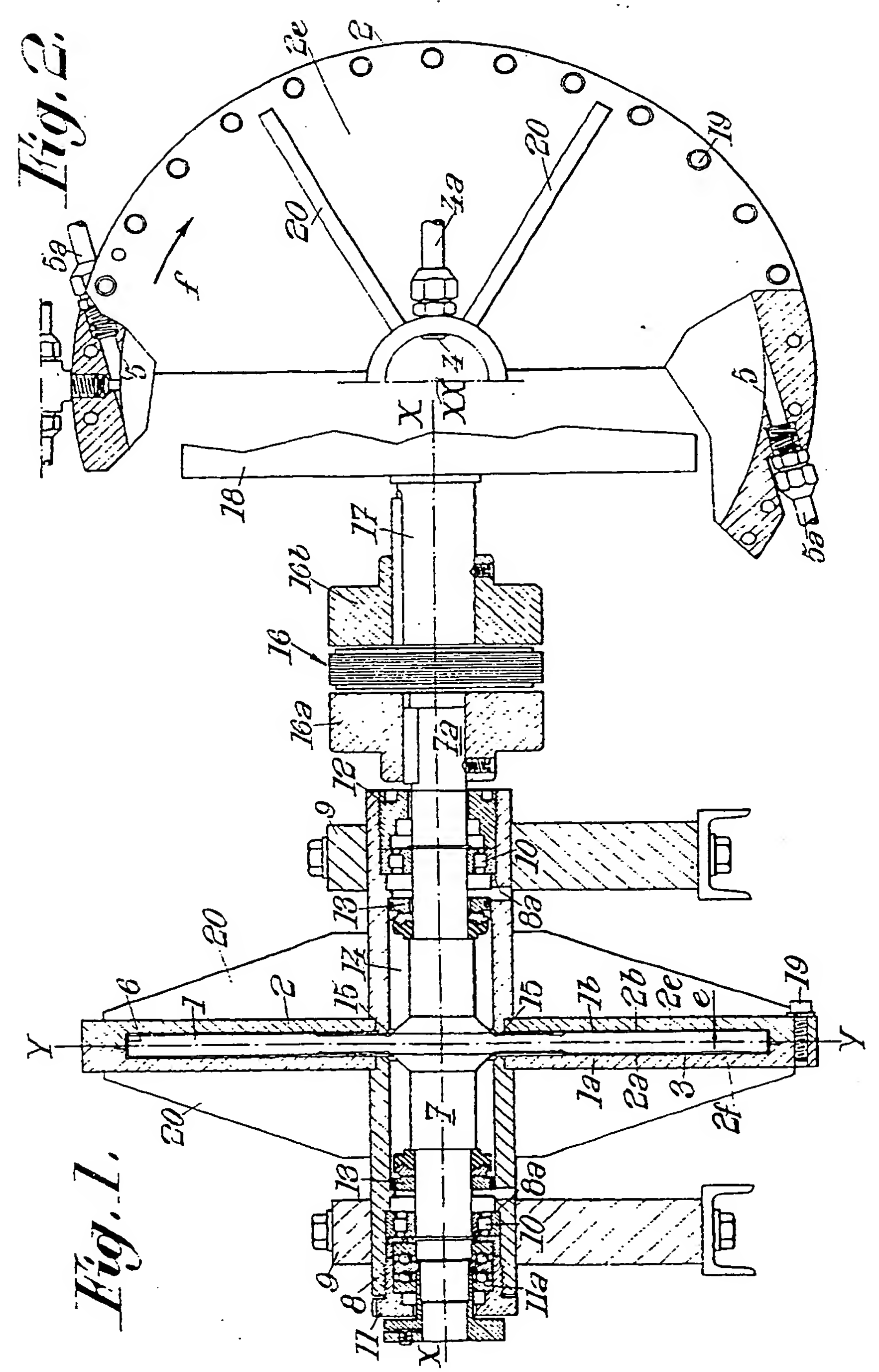

Fig. 1.

Fig. 2.

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SHEET 2

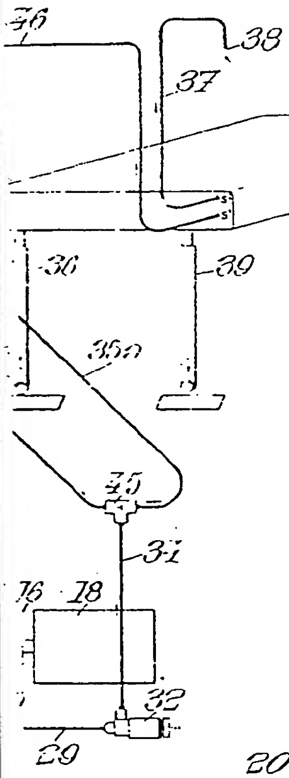
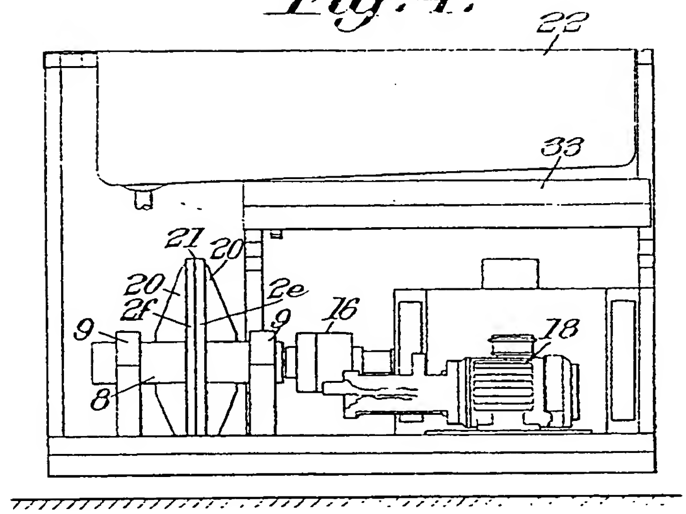
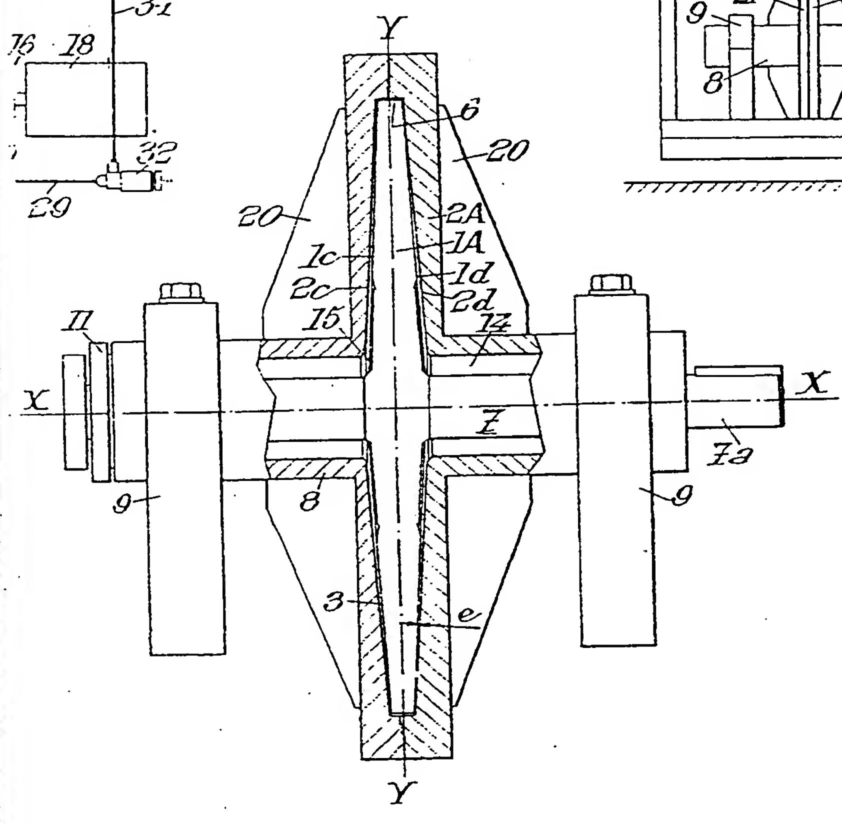


Fig. 4.





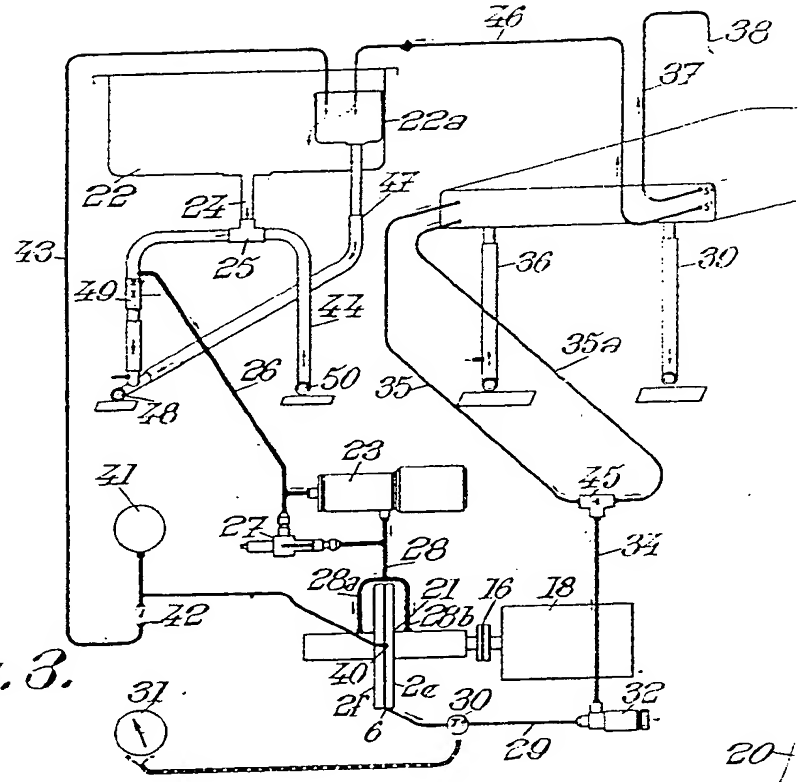

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Fig. 3.

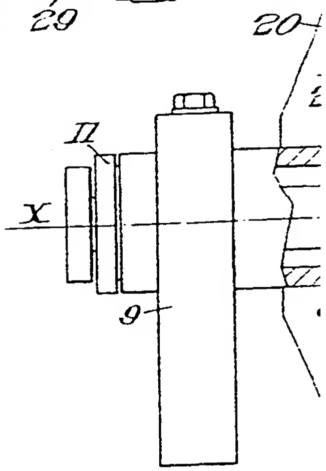
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Fig. 5.

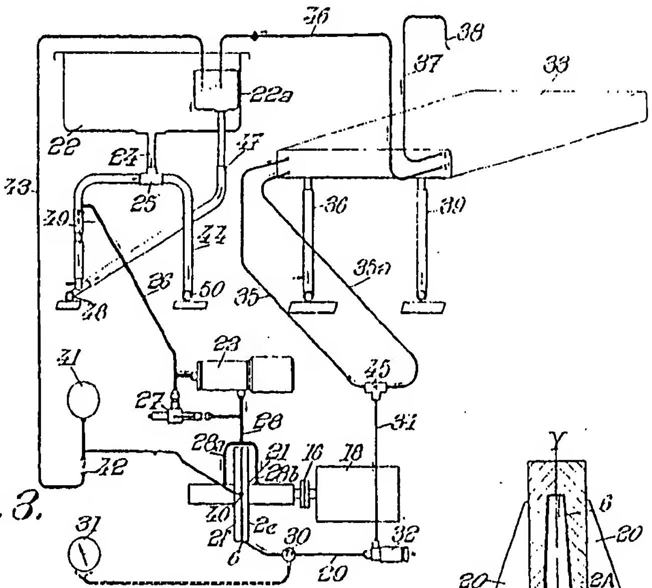
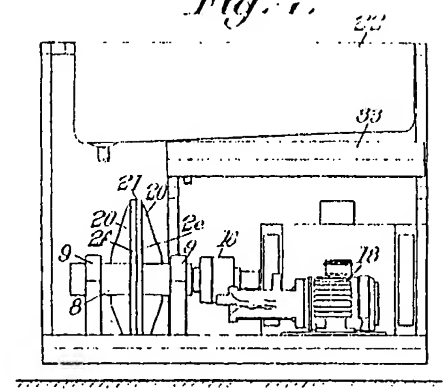


Fig. 3.

Fig. 4.



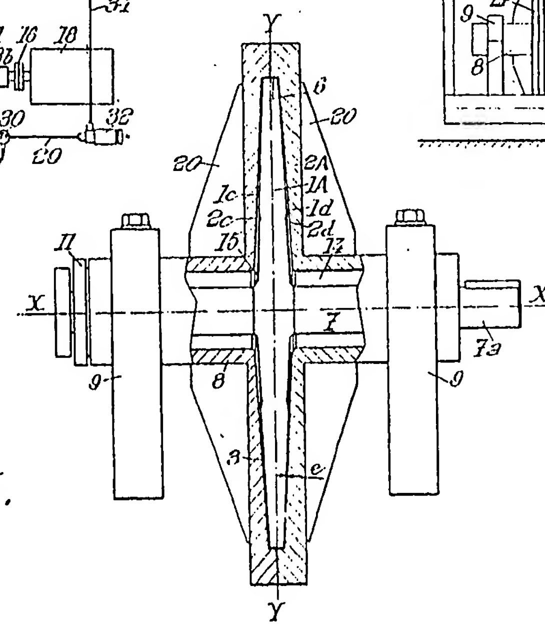


Fig. 5.

1,217,959 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 3

Fig. 6.

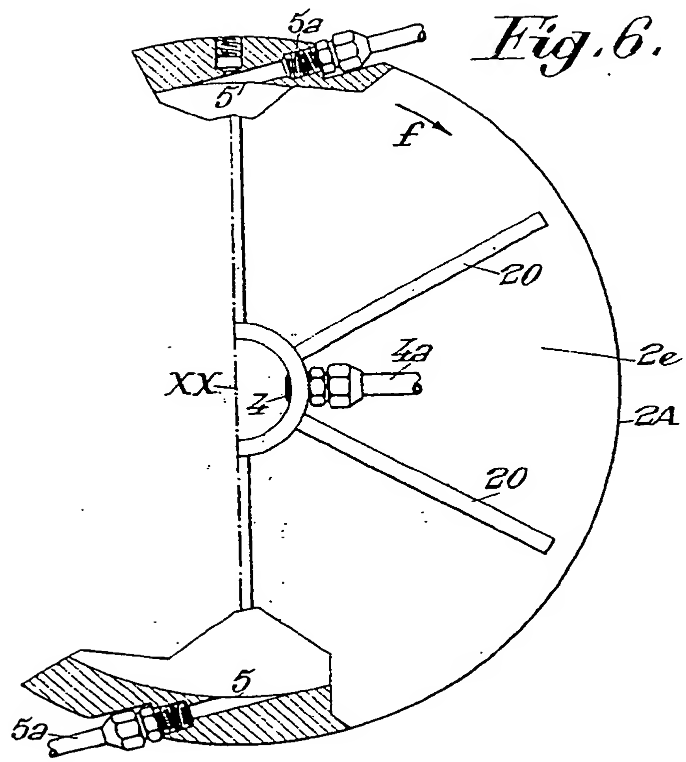
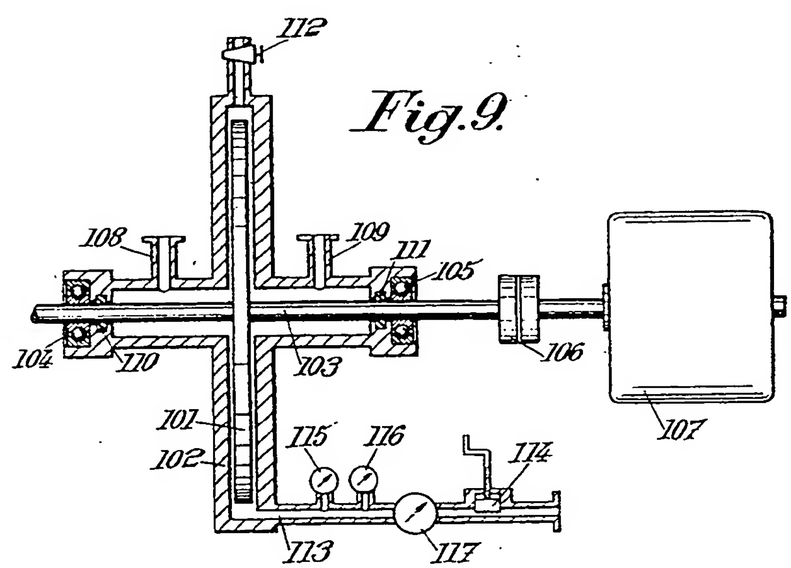


Fig. 9.



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COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

SHEET 4

Fig. 7.

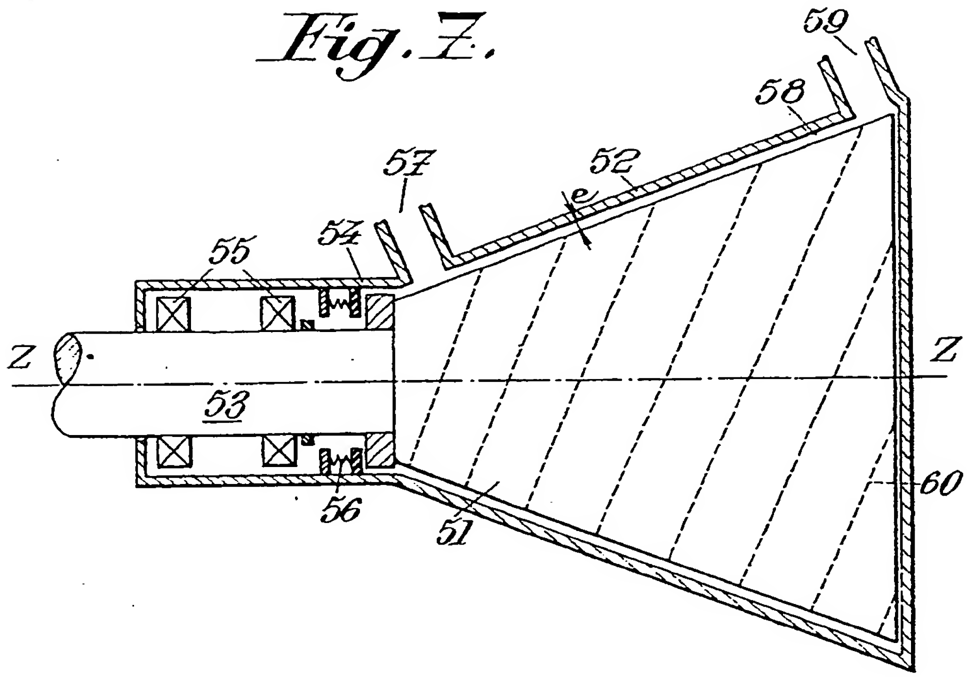

Fig. 8.